MC-12W Systems Study Guide

by

Capt Nick Romano

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**Introduction**

Hello. So, you’re an MC-12W pilot. Sweet. I put this study guide together in order to present some of the MC-12W’s technical systems data in a conversational, digestible format. At this time, the aircraft is a relatively new addition to the Air Force arsenal. Information is somewhat disjointed, being compiled from several sources that are not always particular to our model of BE350. We have some unique electrical modifications, as well as some performance restrictions that have been…….well……..merely estimated. Sometimes it’s tough to pull all the right information from our various and scattered sources. And when you pull it, some of the information is not presented in plain language. That’s where I come in. This guide ties in the principles of system operations with the required courses of action during certain EPs. I hope it will spark some new questions and rekindle your curiosity about the systems we use to keep our aircraft healthy and aloft. My attorney has advised me to put in a disclaimer saying that this is not a substitute for the POH or Pilot Training Manual (PTM). We’re all responsible for understanding and operating according to those documents. Let’s just consider this an abbreviated pilot’s study guide to the MC-12W. Hopefully you will find it easy to read, enjoyable, and helpful.

Version 2

Updates: Fuel System section expanded to include fuel leaks / fuel siphoning.

 Engines / Props section added

Version 3

Updates: Modified content on L/R NO FUEL XFER light and Dual Gen Failure EP.

**Fuel System**

This aircraft has a robust fuel system for a light twin. Each wing has 8 fuel cells (5 per wing + ER + Aux + Nacelle), totaling 775 gallons of fuel. Only the first batch of MC-12Ws do not have the Extended Range tanks. The rest will come standard issue with this mod. This can be both helpful as well as limiting. While the ER tanks enable us to load up with an additional 236 gallons of go juice, the additional drag from those two giant bumps on the nacelle has a considerable effect on our fuel flow. Also, while the additional fuel may boost our sortie durations, the increased take off weights reduce our climb gradients. It’s a balancing act. (The ISR mod is another story altogether.) Currently, we only have the following guidance to plan for the effects of ER/ISR mods:

 11%: Increase fuel flow for range

 11%: Increase fuel flow for endurance

12%: Increase time/fuel/distance to climb

Pretty vague, huh? And that applies to all conditions? I don’t see how, but it’s what we have to work with. For the moment. But let’s forget that now and run a scenario with the numbers we all know and love. The stuff that’s guaranteed.

***Normal Operations***

We’re at altitude now, mission power is set, and we’re cruising to our target area. Our engines are getting go juice from a nicely-designed automated system in each wing. The first fuel supplier in the system is the ER tanks. Motive flow in the ER tanks send fuel to the nacelle tank, followed by motive flow from the Aux tank, and then gravity flow from the Wing tanks. From any of these sources, once the fuel hits the nacelle tank, it’s pumped to the engine by the Primary Boost Pump. This BP is operating anytime N1 is turning, so there are no switches to operate. All automatic. This pump will stop working if we’re crossfeeding (or if we’re above 20,000’ PA and using AVGAS – not likely). In the event our primary BP quits on us, we have a Standby BP ready to go. This pump is electrically powered, and gets it’s electrons from the Triple Fed Bus and it’s respective Generator Bus. The Standby BP earns its pay during crossfeed, since the Primary BP can’t operate in that mode. More on that later. Anyway, the Primary BP is delivering fuel at 1250 pph and 30 psi to our Engine Driven High Pressure Pump. This pump delivers fuel to the engine at 1050 psi. From 30 psi to 1050 psi is a remarkable difference. Well, the High Press BP is the head honcho, and the whole system exists to make sure it has fuel to pump to the engine. If this guy fails, our engine flames out. (Trivia: if you want to geek out completely, you can tell your friends that the fuel passes through a 200-mesh strainer after leaving the High Press BP on its way to the engine). Quickly stated: Motive flow jet pump to the Primary BP to the High Press BP to the motor, supplied first by the ERs, then Aux, then the wing, then nacelle tanks.

We’ve been on station for a while now, and we’ve depleted the ER tanks. But the float switch in each tank is pretty smart. When it senses the tank is empty, it powers a 30-sec time delay relay. This closes the ER motive flow valve and opens the Aux tank motive flow valve. Now the engine is running on fuel from the Aux tank. This doesn’t last too long because the Aux tank has only 79.5 gallons per side. But during that short time, the Auto Fuel Transfer Module is monitoring our fuel state for us. This smart device powers the motive flow valve open, and will function as long as there is fuel in the Aux tank and we have the Primary or Standby BP working. When the Aux tank is empty (or the BPs fail), the Motive Flow Pressure Switch opens, which then moves the float switch contactor to Empty. This float switch sends the empty signal, and after a short delay (6-7 seconds, nerd), our all-powerful Auto Fuel Transfer Module takes electricity away from the Motive Flow Valve. The valve closes, and shortly thereafter (9-13 seconds, jeez) pilots see the L/R NO FUEL XFER light. Now we’re getting fuel from the Nacelle tanks (gravity fed by the wing tanks).

But let’s say there is still fuel in the Aux tanks. We see the annunciator and decide to check the quantity, and there’s definitely gas in the tank. Well, perhaps our all-powerful Auto Fuel Transfer Module isn’t so all-powerful after all. If there is an error in the circuitry, and you know there’s fuel in there, and you need that fuel, you can select an Override mode. This will provide an alternate electrical signal to open the motive flow valve. It’s also important to note that the L/R NO FUEL XFER light will only work when there is fuel in the tank. This is a nice touch, provided by our friend the float switch. When the tank is empty, it tells the Auto Fuel Transfer Module to turn off the light. However, the float switch does this under the assumption that the pilots are aware the Aux tanks are empty.

There’s another thing that closes the motive flow valve, and it’s not always convenient. When your auto igniters start popping (when you reduce power below 17% for landing, for instance), power is removed from the motive flow valve. We know that after the valve closes, we get the L/R NO FUEL XFER lights flashing in our face, usually in the flare. Have you noticed that? This is a smart idea in terms of fuel system design, but has been the cause of some undue complacency regarding annunciator lights and a pilot’s level of attentiveness toward them. Even though we know this light is going to pop on, we must not blindly extinguish the flashing yellow caution light without verifying it first.

For the last part of the discussion on normal operations, let’s consider the physics behind motive flow for a second. A smart man simplified this with a good analogy. It’s like speeding down the interstate while holding a full can of beer out the window. The airflow draws the beer out, and it motively flows all over the road (a cool trick, but wasteful). Similarly, the speedy flow of fuel through the lines (pumped by the Primary or Standby BP) passing through the motive flow valve draws fuel from the Aux tanks into the line going into the nacelle tank.

And that completes the logic of supply and providence when things are working normally. Now let’s move along to abnormal operations and emergencies.

***Abnormal and Emergency Operations***

We’re still on station. Our ER tanks are depleted, and we’re running on the Auxs. Let’s say our L/R NO FUEL XFER light, comes on. We know we have fuel in the Auxs, and we need to stay on station. We select OVERRIDE, but nothing happens. It’s probable that our motive flow valve has been stuck closed during a transient condition, or has lost its electrical power. And guess what? All that fuel is trapped. Time to make some plans. Recompute your time on station and pick out some good divert locations if you can’t make it back home. But then again, maybe you can confirm that fuel is still transferring. In some cases, a sick float switch neglects to tell the Auto Fuel Transfer Module to turn off the light L/R NO FUEL XFER. Now you just have to deal with the light until MX can get to work on it. But you better make sure it’s transferring before deciding to ignore it.

Let’s try another one. After hours and hours, it’s finally time to go home. 30 minutes out, we see a L/R FUEL PRESS light illuminate. This means the pressure in the line supplied by our Primary BP (normally operating at 30 psi) has dropped between 9-11 psi and is decreasing. Easy fix – turn on the associated Standby BP, and the light should go out. Anyway, Standby BP to the rescue, right? Well, what if that back up fails? Now our High Press BP is suction lifting fuel from the Nacelle tank. This is limited to 10 hours before the pump must be overhauled. If it operates more than 10 hours on suction lift, the pump must be replaced. In addition, losing the Primary and Standby BP will stop the pressurized fuel required for motive flow, which will trap the fuel in the Aux tank. This will definitely interrupt the course of your day.

What if we stayed on station too long before returning home? Poor planning may result in a L/R FUEL QTY annunciator light. The light comes on when the system thinks we have 300 lbs (45 gal) remaining, or 30 minutes of fuel at max power. There is a 5-7 second delay built in to guard against the light coming on when fuel is sloshing around. Interestingly enough, the same logic applies to the delays associated with the L/R FUEL PRESS light (9-11 psi and decreasing) and the L/R NO FUEL XFER light (9-13 seconds). We don’t want the lights firing as a result of transient conditions caused while maneuvering.

But we’re smart flyers, and we’re gonna leave our target area when we hit our bingo. Right? And we’ll fly home on two engines. Unless one of the engines fails, or gets shot to pieces, or simply misbehaves and needs a good shutting down. But just because we’ve lost an engine doesn’t mean all that fuel is trapped. The left wheel well houses our crossfeed valve, which allows pilots to feed fuel from one tank to the opposite engine (not tank to tank). We’ve shutdown an engine, and we need to crossfeed fuel from the inoperative side to reach a suitable airfield. We move the crossfeed switch in the direction of desired flow, powering a solenoid which opens the crossfeed valve. Additionally, this switch sends two messages to the famed Auto Fuel Transfer Module:

1) Energize the Standby BP on the feeding side.

2) Deenergize the motive flow valve on the side being fed.

While crossfeeding, we must pay attention to some very crucial details. Let’s make a list:

1) We must have the aux transfer switches in AUTO to receive fuel. In OVERRIDE, the motive flow valve remains open. Incoming fuel would start filling the Aux tank through the aux transfer line and could result in fuel being dumped overboard through a vent port.

2) Leave both Standby BPs OFF. The crossfeed system will automatically turn on the pump it needs to establish crossfeeding (during the fuel system test on preflight Standby BPs are off).

3) Due to lack of motive flow, aux fuel on the side of the inoperative engine will be unavailable for crossfeeding if the Firewall Valve was closed during shutdown.

4) WARNING: With a primary fuel source, one operative Standby BP is required for takeoff; however crossfeed will not be available from the side with the inoperative Standby BP.

5) If using AVGAS, crossfeed must be available for climbs above 20,000 ft.

OK, let’s do another on-station scenario pertaining to crossfeed. What happens if we haven’t checked for a while, and then somebody notices a 325 lb fuel split? Are we allowed to use crossfeed to resolve the imbalance? No. Why not? Because it’s very tricky business and requires a lot of attention. The POH just says we can’t do it, but doesn’t warn us of the possible consequences. Such as becoming distracted and running the feeding tank dry, which would result in a flameout. It’s increasingly dangerous if feeding a side with an inoperable Standby BP. Consider the result if we became distracted and ran the feeding tank dry in this situation. The feeding engine would flame out, but could the High Press BP on the receiving side establish suction lift quickly enough to prevent a flame out from momentary fuel starvation? No, it couldn’t. And there you are, strapped in to a very expensive, very heavy glider that’s negotiating with gravity. In theory the engine could fire right back up with a Windmilling Airstart, but you better have the checklist handy if you make that mistake. Fuel imbalances are best handled by flying with an asymmetric power setting to offset the fuel flow and close the gap.

Last scenario. Let’s go back to that 325 lb fuel split. Before we blindly accept this substantial fuel imbalance and begin trying to correct it, we should ask why we have a split in the first place. Nobody in their right minds would arrive on station and decide to run some single engine simulations. The numbers should be pretty even, since normal cruise fuel burn should not differ by more than 10-20 pph. Do some math, figuring an average of 500 pph fuel burn. Since we took off, how much fuel should remain in each tank? It’s possible that fuel has siphoned from the cap, or leaked from a tear in the aircraft skin. Fuel siphoning results from improper seating of the fuel cap. We guard against this on our preflight, ensuring that the cap is flush and pointed aft. You’ll see some clear liquid (fuel, duh) pooling in the cap and streaking back. The POH doesn’t specify an airspeed that will minimize siphoning, but other King Air POHs recommend 140 kts. If we can’t confirm a siphon, we may suspect a fuel leak. Evidence may include a strong smell of fumes in the cockpit, or visually confirming streaks of liquid on the surface of the wing or streaming from the trailing edge. The Sensor or CO will have the best vantage point to confirm. The crew’s biggest concern is to guard against the development of a wing or engine fire. Our POH doesn’t mention fuel leaks or the appropriate course of action, but other King Air POHs recommend a shutdown if the power is not necessary to sustain flight or reach a safe destination. Since we have no guidance, it’s dealer’s choice. Weigh your options and choose carefully.

 These are some of the key limitations with our fuel system. We’ll stick with the list format.

1) Operating with a L/R FUEL PRESS light is limited to 10 hours TBO.

2) Max zero fuel weight is 13,000 lbs. Max fuel imbalance is 300 lbs.

3) Approved primary fuels: Jet A/A1/B, and JP 4/5/8.

3) Emergency fuels: 80/87, 91/96, 100LL, 100/130, and 115/145.

4) Max operation with AVGAS is 150 hours TBO. Both Standby BPs must be working.

5) Refuel the main tanks first, then aux tanks, the ER tanks.

6) Do not take off if fuel quantity indicates in the yellow arc (265 lbs or less).

7) Crossfeeding is only permitted with one engine inoperative.

8) Minimum known or forecast OAT without fuel anti-icing additive is -45C. Always use PRIST if fueling at an FBO.

For now, that’s enough fat to chew from the fuel system. Let’s move on to something a little more challenging.

**Electrical System**

The electrics for the BE350-ER were laid out with redundancy and component protection in mind. To adapt to our special requirements, a few of Uncle Sam’s engineers have manipulated/added to/reconfigured/modified some of the wires and buses. Hopefully they’ve kept redundancy and component protection in mind too. Anyway, all of their ingenuity totals up to a new machine we all know and love: the MC-12W. Keeping this thing in a healthy flying condition requires a robust understanding of the electrics. We must know what to expect during normal operations so that we can tell when something is abnormal. Some the indications are indirect, and only hint at impending problems. Other times, the aircraft will warn you in a straightforward manner. But each sequence of switch positioning and light illumination is significant. We’ll start with a discussion on how it works when everything is in tip top shape.

# Normal Operations

Before we fly, there are tests we perform for many of the components on the electrical system, some without knowing it. For instance, the checklist doesn’t explicitly call for a current limiter check, but you check them every time you fly. During preflight, the first thing we check is the flow of electrons from the battery to each of the components. This gives us a warm fuzzy that we’ll be able to get by (for a little while) if our generators go out.

Our battery is a 42-Amp hour lead acid with two functions: 1) Starting power, and 2) Emergency power. On battery power only, a quick glance at the ammeter and some simple arithmetic can help you predict when all the lights are gonna go out. Before we turn the battery on, we move the BAT BUS switch from EMERG OFF to NORM. If you see the LED clock on the control wheel working, then your battery bus is powering the dual fed bus. And that’s your only indication from the pilot’s seat. It also means your fire extinguishers are ready to discharge, should you need them. Then we turn on the battery and go to the voltmeter. We make sure only the triple fed and center buses are powered. Good, the generator ties are open. We manually close them, and juice flows through the center bus to the generator buses. We check the generator voltage, and a good indication tells us that electricity is flowing through the center bus, through the gen ties, and up to the gen buses. This also verifies that your 250A current limiters are intact. A blown current limiter will prevent flow to the gen bus. And, it’s possible for a current limiter to have failed the flight before without any noticeable indications. Now you can impress your MX guys with your insane troubleshooting abilities if you ever close the gen ties and have 0V on one of your gen buses.

*Note: The BE350 Pilot Training Manual says the triple fed bus cannot conduct electricity, but that’s not true. It’s wired directly to the dual fed bus, which it will power in the event that your battery dies in flight as a result of a dual current limiter failure.*

At that point we can apply external power if it’s available. We just need the battery to show 23V or more. And if it shows less than 20V, we need a charge or a new battery altogether. But today the battery is healthy, and our lineman plugs it in. In a few minutes it’s time to crank motors. Electricity flows the same way during a GPU start as with a battery start. When we move the IGN AND ENG START switch to ON, the battery relay closes to connect the GPU and the starter/generator. The HEDs are disabled so they won’t open their respective bus tie relays. Electrons flow, and the prop turns. Cross generator starts are a bit more complicated. The reason we move the condition lever to high idle is to increase the RPM of the generator to maintain bus voltage during the heavy loading required by the start. The first stop the power makes is at the generator control unit (GCU), which limits the generator output to 400A to protect the 250A current limiter. Additionally, the power has to travel through two buses, two HEDs, a bus tie, and a current limiter.

Let’s tackle the subject of these GCUs before we move on. They have five primary functions:

1) Voltage regulation at 28.25 +/- 0.5

2) Overvoltage / overexcitation protection at 32V

3) Paralleling and load sharing at 10%

4) Reverse current protection

5) Cross gen start current limiting at 400A

To further elaborate, the GCUs are constantly comparing engine speeds and load requirements to ensure the generators are providing steady voltage. If a generator fails, the GCU automatically isolates it from the bus. If the generator becomes underexcited and tries to draw voltage (reverse current) from electrical system, the GCU opens the line contactor to protect the generator. We test the GCU after we start engines by holding the R GEN switch to the UP position momentarily. This takes the right generator offline, indicated by the illumination of the yellow R DC GEN light. When you release the switch and the light goes out, that means the GCU has decided the generator is OK and is regulating the voltage to 28.25 +/- 0.5V. Outside that limit, the GCU will prevent the right generator from coming back online and your R DC GEN light will stay illuminated. Time to call MX and boggle their minds with your troubleshooting prowess.

After engine start, we do the Electrical System Test. Now it’s time to test the automatic bus tie sensors. Selecting the TEST position isolates the center bus – essentially, this is just a test to see if our Hall Effect devices (HEDs) are working. A good test means we can isolate our center bus if we need to (and soon we’ll talk about why we may need to). These few simple tests have told us the following components are alive and well: dual fed bus, HEDs, gen ties and battery tie, and current limiters.

Now you’re sure the airplane you’re taking up is electrically healthy, and should work as advertised. Bon voyage.

# Modifications

Mr. and Mrs. Filthyrich would gasp in horror if they saw what Uncle Sam’s engineers did to their beloved King Air. All that ungainly equipment blocking the aisles……where would they put the ice buckets for the champagne? Lucky for us the engineers gave us a master switch for all that stuff, called the MISSION POWER switch. This switch is part of the reason we now have an ISR supplement to the POH. The sup identifies the MISSION POWER switch as a big player in two of our emergency procedures, and modifies the checklist for Liberty 8 and on. Also, it posts numerous warnings for blocked hatches, taxi restrictions, and danger zones from blazing electrons, lasers, and moving parts. Not to mention an equipment list that was issued defining the vast array of components they wired into our electrical buses.

The important message is that although the one-switch design seems simple enough, our guidance for operating the associated systems and handling emergencies is somewhat scattered. The first time to go searching for info is not in a dark cockpit when a strange light pops on.

# Abnormal / Emergency Operations

We’re back on station again. To this point we’ve had a normal mission, no troubles. A circuit breaker pops. If it powers a component you don’t need, leave it alone. If you need it, give it 10 seconds to cool and reset it. But only once. Anymore than that and you’re taking a chance of sparking an electrical fire.

Let’s review the CB color coding logic for a moment. The color code indicates the component’s respective bus assignment. Seeing a yellow-ringed CB pop might tell us to look for normal operation of other components ringed in yellow. If everything is operating normally, the component kicked off line for some reason or another. If you have a few popped yellow CBs, this could be an indication of an impending problem with the bus. In all cases we want to troubleshoot potential bus problems by investigating indications from the other buses and related equipment, as well as voltage and loading status. Also, it’s time to crack open the component list and see what else you might be saying goodbye to in the near future. Here’s the color scheme:

Yellow = Triple Fed Blue = Left Gen Green = Right Gen

Red = Standby Bus White = Battery Only

Only four CBs are circled in red. Particulars about the standby bus are not outlined in the POH, but it is depicted on the electrical diagram. We’ll see later that this elusive standby bus plays a huge role in the most potentially dangerous of the electrical malfunctions – the dual generator failure.

Before we get too deeply into electrics, here is a good sequence for your eyeballs to follow as you peep around for impending doom. Switch, Circuit Breaker, Bus, Component. Something stops working. Is the Switch in the correct position? If so, did the CB pop? If so, does the Bus indicate any other equipment malfunctions? If so, how do we live without those Components? This sequence is a good start as you reach for the checklist.

For now, let’s do another malfunction. A yellow annunciator light pops on: BAT TIE OPEN. Any time a tie opens, the HED sensed too much current blasting through the lines (275+/- 5) and did its job. It could’ve be a transient surge, so the checklist tells us to check the battery. If the battery is alive and well (24-28V), we can reset the BUS SENSE switch. The mission goes on and we monitor it occasionally. But what if the center bus is reading 0V? That’s not good, and we’ll see why it may end the mission. But first, we need to protect the generator buses from a berserk center bus, so we’ll select the GEN TIES switch to OPEN and make sure the L/R GEN TIE annunciators come on. The checklist will tell us to pull the LANDING GEAR RELAY circuit breaker, but won’t tell us why. If you look on the component list for the center bus, you’ll see the landing gear motor listed. Eventually we’re gonna have to hand crank the gear down, because we’ve electrically isolated the battery and cannot charge it. We’re pulling the gear relay CB now so we don’t forget later. If we don’t pull the CB and select the gear handle down (an inevitability – it’s part of the manual extension procedure), we may damage the electrical system and further complicate the flight. Here’s an interesting discontinuity: the checklist doesn’t tell us to turn off the air conditioner before landing, but the BE350 Pilot Training Manual does (although it doesn’t say why). The condenser blower is located on the center bus, and with the BAT TIE open and the GEN TIES open, it’s not getting power anyway. So we have no way to manufacture cold air, and the equipment in the MC-12W doesn’t do well in hot temperatures. In the end a BAT TIE OPEN annunciator could possibly signal an early RTB. Also, now’s a good time to look at that ammeter and do some math to figure out when our battery is gonna quit on us. If the generators are working, they’re picking up the lion’s share of the loading and the battery should last for hours. But we’d run the numbers anyway. There’s one more thing worth mentioning. Manual prop deice is on the center bus – let’s make sure to select AUTO (provided by the left gen bus) if we need to transit through icing.

What if it was a L/R GEN TIE light that came on instead? Again, the HED sensed some extra juice and opened the tie for us. Just like the previous malfunction, the checklist tells us to go straight to the load meter. If the load is less than 100%, we can attempt a reset. This could’ve been a transient condition. If the generator is at an abnormal voltage or pegged at 100%, turn it off. Now the other gen is powering the center bus, triple fed bus, and charging the battery. That’s a lot of work, so we need to make sure it didn’t spike to 100% also. If so, we need to reduce the load. Time to consult the list of components and see what we can live without. What about if the light comes on, we check the load meter, and it’s indicating normally? We try to reset the BUS SENSE switch, but nothing happens. The checklist just tells us to monitor the loads, but stops there. This is a curious oversight. Let’s think about it for a second. In this example we still have two healthy generators. But the GCUs can’t do their paralleling magic because a gen tie is open. So the loads will not necessarily indicate within 10% of one another. Something obvious like a 20% split might lead some pilots to mistakenly diagnose a sick GCU (no paralleling). A sick GCU might be a deal breaker for us, and could be cause to bebop on back home for some maintenance. But that’s not the case. We can still continue our mission, as long as each generator stays below 100% total load.

Before we get to the big stuff, let’s try a sneaky one just for the sake of the conversation. How could we tell if both current limiters failed in flight? In truth, this is highly unlikely in the normal BE350. The 250A slow-blow current limiters can handle heavy loadings. But the MC-12W has been substantially modified, and there is a lot more current flowing to/from the buses. Anyway, if both gens are operating normally, all of our equipment will be functioning even if both current limiters have blown. But, our battery can’t charge. If we’re very attentive we’d be able to figure it out by noticing a discharge on the battery. You do check the battery charge on your periodic systems checks, right? Of course you do. So, the battery is powering the center bus, and as we noticed before, the center bus powers the air conditioner. The AC draws a lot of electricity and the battery is gonna go bye-bye quickly. So, if we’re on station and our AC quits on us, it could mean one of two things: the AC just quit, or the battery died. Straight to the ammeter we go. With a positive charge, we know at least one of our current limiters is intact (but hopefully both). If the battery is dead, we’ll review the manual extension checklist as we RTB. Take another look at the *Note* in the Normal Operations section. If the triple fed bus couldn’t conduct electricity (like the PTM says) and our battery died, we would lose our fire extinguishing capability on the dual fed bus. Lucky for us that’s not the case.

Are you ready to dive deeper into total nerdhood? Let’s get into the weeds a bit, just for the sake of talking systems. Environmental systems in older King Air models featured both the evaporator and condenser blower in the same section of the nose, connected by the same manifold. And if the AC was working hard in the warm air on the climb up to altitude, there would be a lot of condensation pooled in the manifold. When the OAT dropped below 0C, the condensation in the manifold would freeze and restrict the flow of the freshly chilled air. The blower would work too hard and the system would simply kick offline to prevent damage from overworking. But the engineers learned, and in the K350 they separated the condenser and the evaporator to prevent this. Our condenser is located by the wing root and pushes air through a separate manifold. But that doesn’t mean the condensation by the evaporator doesn’t freeze. It will, but the condenser will still operate normally. When you eventually descend to a warmer altitude, the frozen condensation will melt. The manifold drain vent is by the nose wheel door. Sometime during a summer post-flight walk around you’ll notice a huge puddle developing. That’s all the moisture that was condensing and freezing at altitude, and is now melting all over the ramp.

That’s the nerdy trivia part, but here’s the real beef. Think back to the BAT TIE OPEN conversation for a minute…..we said a BAT TIE OPEN annunciator could possibly trigger an RTB because the equipment might overheat. In the event of a BATT TIE OPEN light (and the center bus at 0V) or a dual current limiter failure, we’re gonna secure the cabin temp mode to save battery life. But the left gen will power the vent blower and your battery draw will be minimal. If it’s already cold in the aircraft, you may be able to stay on station with the vent blower circulating the cold air if you’ve computed sufficient battery duration.

Now we move on to the big EPs: Generator Failures (cue ominous music). The first important detail is that the ISR Sup modifies the POH checklist for generator failures. A new addition to both the Single and Dual Generator Failure is MISSION POWER Switch – OFF. (The ISR Sup also modifies Electrical Smoke or Fire to include MISSION POWER Switch – OFF, but we’ll tackle that in another section). As soon as we kill that switch, we’re no longer able to conduct our mission. A single gen failure may be recoverable, but a dual failure is a deal breaker for MC-12W crews.

Let’s talk about a single generator failure first. If we see a L/R DC GEN light, the first step is to remove mission power. Sometimes a GCU will take a generator offline for a transient condition, and we’ll be able to reset it without further malfunction. But is it possible to realign our equipment in the air after shutting it all down with the MISSION POWER Switch? Yes, it is. Terrain/traffic/weather permitting, we set the autopilot for straight and level flight and allow the sensor equipment to realign. Then we do some S-turns for the sensor operator, and we’re back in business after a few minutes. If we can reset the generator, we can leave it on and monitor it as we continue the mission. If the generator does not reset, we’ll check that the operating generator is not pegged at 100% and start heading home. If it is pegged, we need to reduce the load by turning off non-essential equipment. And start heading home.

In the MC-12W, a dual generator failure is one of the most serious and time critical malfunctions crews can experience. At night it’s significantly worse. The first step in the checklist is to turn on the Instrument Emergency Lights (if we need them). Let there be light. Then the ISR sup modifies the traditional procedure and tells us the second step is MISSION POWER Switch – OFF before attempting to reset the generators. If we’re lucky enough to get one or both to reset, we’ll continue with the checklist as we turn toward home. As we said above, losing one generator and successfully resetting it may not be that worrisome. But losing both generators simultaneously is indicative of impending catastrophic electrical failure, and smart pilots will make a beeline for home.

When both generators fail, the gen ties open and load shedding occurs automatically. The battery will power items on the center, triple fed, dual fed, and bat bus. A quick scan of the toggle switches with a white-ringed CB will indicate which components you can expect to remain operational. Refer to the Load Management Table in the POH (or Pilot Checklist book) for specifics, and get rid of the stuff you don’t need. You’ll notice that some of the equipment is listed as “Continuous.” That’s a little misleading. A small note printed in microscopic font will tell you that “Continuous” really means 30 minutes (based on a 50-amp load). It’s also based on a battery with a 75% charge, but the POH neglects to mention that. When you see equipment with a time value listed, subtract that from the 30 minutes to get the actual expected battery duration. Whatever we do, we’re not going to move the GEN TIES switch to the MAN CLOSE position. This will reconnect the L/R generator buses and severely reduce our battery life. We’ll check the ammeter frequently and run the numbers to see if we can make it to our selected airfield, or if we need to find something closer. The copilot’s PFD will shed and go blank. Attitude reference will be available on the pilot’s PFD and the ESIS (powered by the elusive standby bus with the red-ringed CBs). If the battery dies before you land, you only have the ESIS to get you home. Always insist on a precision approach, because the ESIS glide slope will be your only measure of vertical performance (it doesn’t have a VVI – oops). Another minor inconvenience – the POH doesn’t tell us how long to expect the standby battery to power the ESIS – double oops. The checklist says we’ll be making a flaps-up landing and manually extending the gear – not an easy operation in the dark. Lastly, going to a short field may not be the best choice, because the ground stop solenoid will be inoperative. This will greatly reduce the effectiveness of ground fine and reverse. Better make sure our destination is going to be long enough. But wait, we don’t have TOLD for landing distances with our props stuck in flight pitch. The unofficial final step of the checklist: cross our fingers.

Okay, that was a useful exercise in demonstrating just how complicated one malfunction can get. And the snowball effect just piles everything up. Running the checklist is a start, but will not take you to the finish line. The clock doesn’t stop, and the information we need is in scattered sources. Pilots who are not intimately familiar with the required course of action beyond just running the checklist are flying with luck as their only hope.

One last tidbit to share. It should be a little disconcerting that the POH doesn’t tell us how long the ESIS (model TP-560 GH-3100, for you nerds who care) will operate with a total power failure. The Load Management Table simply has a note informing us that the ESIS has its own independent power source. And the electrical diagram in the POH depicts the standby bus wired to the left gen bus. But how long will it last? Look until your eyes bleed, the POH won’t tell you. It does, however, require the TP-560 GH-3100 user’s manual to be immediately available to pilots during flight. Surely some info on expected duration is listed in the manual, right? No. It’s not. Only a call to L3 tech support (1-800-453-0288) will reveal the power scheme for the Electronic Standby Instrument System. The standby emergency bus in the BE350 is either a PS835 or a PS850 model. According to two L3 tech reps (I wanted multiple confirmations), it also contains provisions for comm, nav, and audio. Look at the red-ringed CBs under the fuel panel – you won’t find CBs for that stuff. But you will see a CB for a heading sensor that uses the copilot’s pitot static source. The tech reps said if the ESIS test light illuminates during your preflight checks, you should get at least 30 minutes of operation from this bus. If you limit your transmissions, you might be able to get an hour out of it. Bottom line: You’re on borrowed time. Don’t pass up a suitable airfield just to get someplace only marginally better.

**Engines and Propellers**

Our Canadian friends at Pratt and Whitney have developed a very reliable turboprop engine in the PT6A-60A. The PT6A model is the most popular design in the history of propeller aircraft and has a superb record of reliability. This allows us to fly and maneuver and wheel and soar with confidence as we slip the bonds, surly or otherwise. There are a lot of automatic features that keep the engine running efficiently, and if it decides to break down the prop will usually streamline itself. The POH and Pilot Training Manual have a lot of in-depth diagrams and text descriptions. You can get into speeder springs and flyweights or dissect individual components if you want, but there are simpler ways to describe the PT6A’s basic functions (and abnormalities, of course).

# Normal Operations

First we’ll talk about engine operation, then prop operation. To understand the engine in simple terms, it’s easiest to relate power lever movement with aircraft acceleration. This will serve as the premise for the upcoming topics. When we add power we’re talking directly to the Fuel Control Unit, which is a hydro-mechanical computing and metering device. To properly interpret lever advancement, the FCU compares N1 speed and lever position, and concludes that we want to go faster now. The FCU directs more fuel flow through the 14 spray nozzles, which blast it into the combustion chamber to create a bigger explosion to provide expanding gases (insert fart joke here). These gases flow through the compressor section and increase N1 (which is essentially just a measure of generator speed). Independently, the expanding gases also flow through the power section, which exists to convert the gas flow into mechanical action to drive the prop. Increasing the rotational speed of the turbine shaft is the FCU’s ultimate goal (after all, the generator is an accessory). So, the turbine shaft is trying to rotate faster. In fact, at 1700 RPM it’s already rotating at 29,920 RPM, then being reduced to something more usable by the reduction gearbox at a ratio of 17.6:1. Do the math, it works. The RGB exists to convert high speed / low torque at the power turbine to high torque / low speed for the prop. Viola, the FCU’s work is done. For now, let’s forget about it.

At this point, the power shaft is trying to rotate faster. The Constant Speed governor (let’s call it the primary governor) prevents that from happening by regulating oil pressure in the prop dome. For some, it may be easier to relate prop operation to oil pressure rather than speeder springs and fly weights. Pick your poison, the result is the same. All these expanding gases try to make the prop spin faster, but the governor steps in to keep the RPM at the setting we’ve chosen. To regulate RPM, the governor will dump some oil to change blade angle. (\*\*Nerd Alert \*\* Dumping oil enables the feathering spring to contract, which changes the blade angle with a direct connection to the pitch linkage). This increase in blade angle causes the prop to take a bigger bite of air, thereby increasing the torque loading and countering the prop’s natural tendency to accelerate. The blade angle is in flux constantly during flight, normally between 30-45 degrees. To prevent the angle from dropping too low, each prop has a safety feature called the flight idle low pitch stop. This is a mechanically actuated hydraulic stop that keeps the blade angle from going below 12 degrees in flight (which would be bad). Anyway, a bigger bite of air means an increase on our torque gage and noticeable acceleration, both of which are expected results of moving the power levers forward. Did you get all that?

Here’s a quick summary up to this point: We move the power levers forward. Each FCU calls for more fuel, which makes a bigger explosion. Gas flow increases, spinning the compressor and power turbines faster. The RGB steps down the power shaft’s rotational speed to spin the prop at 1700 RPM. The primary governor senses the acceleration and dumps oil to increase blade angle, thereby maintaining 1700 RPM and increasing engine torque. We go faster.

The relationship between increasing blade angle and decreasing oil pressure is crucial to appreciating the safety design in the prop system. We’ll talk specifics in a little bit, but for now let’s realize that if we lose all our oil pressure, the blade angle will increase toward feather. It automatically streamlines us in the worst of the governor failure modes. An uncommanded feather is worse than an overspeed – with an overspeed, at least we’re getting usable thrust for the time being.

Decelerating works oppositely. The primary governor manipulates the speeder springs and flyweights by enabling oil to build up in the prop dome. The best example of this is during a landing in which we use maximum reverse. Airborne, our oil pressure is set for the power (airspeed) we’ve chosen. When we pull the levers back for descent, an increase in oil pressure flattens the blades. When we land, a squat switch powers some nerdy magical components which enable oil flow to the dome. The hydraulically-actuated low pitch stop retracts, blade angle drops below +12 degrees, oil pressure increases. This effectively creates the ground idle stop, limiting blade angle to +2 degrees. The levers come up and over the detent into ground fine. Magic happens, increasing oil pressure, which creates the stop at zero thrust (or ground fine). The levers come up and over the detent into full reverse. Similar magic happens, oil pressure skyrockets as the dome moves to its most forward position, creating the stop that drives the props into full reverse (-14 degrees).

Here’s a final point to complete the logic of oil pressure and blade angle: power levers and prop levers have a different effect on the primary governor. Power forward = pressure decrease. Props forward = pressure increase. Pushing the props full forward requires an increases oil pressure to flatten the blades. Doing this too quickly can have a cumulatively long-term negative effect on the seals in the prop dome. So, we’ve been taught to push them forward nice and easy.

Side note: You may have noticed an occasional directional swerve during taxi, often when you add power from a dead stop. Pushing the levers beyond 68-70% N1 de-energizes the ground idle stop, and the blade angles shoot beyond 2 degrees. Sometimes this happens at not precisely the same time. Similarly, you’ve noticed this during landing rollout. When we touchdown, the ground idle stops engage a split second off, and we veer to the left or right. (\*\*Double Nerd Alert\*\* The 68-70% range actually has nothing to do with N1. There’s a microswitch in the throttle assembly located at the approximate place where lever position normally corresponds to 68-70% N1)

***Abnormal and Emergency Operations***

An engine system as simple as the PT6A has very few failure modes. Powerplant malfunctions include flameout, engine driven high pressure pump failure, and fire. Prop malfunctions include governor failures and linkage failures. Some indications of impending failures include roughness or vibration, high/low oil pressure, surging torque/RPM, chip light, or dark exhaust smoke pouring out of the stacks. Sometimes we can restart an engine, most of the time we can’t. Some cases are black and white, others are rather tricky. Either way, being able to anticipate what our machine is going to do is helpful. And if we can’t do that, understanding the subtle differences in malfunction indications will improve our chances of successfully recovering the crew and aircraft after a malfunction.

Back to the stack we go, converting fuel into noise. Without warning, the aircraft yaws left, and we see the gages for the left engine winding down. First, we’ll power up the healthy engine and balance the rudder. This is essential in any power loss situation, and we’re going to treat these two crucial actions as the unofficial first step in any power loss situation. Anyhow, we could have had a flameout or a prop governor failure. Either way, we have an engine that decided to interrupt the flow of our day. We’ll talk about each of these cases in order.

Flameouts are caused by tons of things. They’re normally caused by problems in the explosion sequence, and are typically characterized by N1 winding down to zero. The fuel temperature may have dropped below the combustion temperature, or there may have been insufficient airflow to support combustion. In addition to N1 winding down, we’ll notice a big drop in the other indications, but we may notice some fuel flow indicated. Much less, but some. In other cases, flameout may result from high pressure fuel pump failure. This type of malfunction is characterized specifically by zero fuel flow. It’s a very fine distinction, and perhaps inconsequential, but we’re talking systems, right? Other culprits include severe turbulence, icing, and fuel starvation (duh). This one is black and white. Shut it down (only after adding power and rudder).

A primary governor failure is not black and white. The POH doesn’t talk much about it but the fact is that the primary governor fails in one of two ways: it’ll feather or overspeed. Let’s stick with the example above, in which we had a power loss and yawed left. In an uncommanded feather, you might see a momentary spike in torque as the blade angle increases rapidly, and then it will wind down as RPM begins to decrease. A scan of the instruments will indicate normal N1, oil temp/press and fuel flow indications. It’s the governor that failed, not the engine. We’re gonna power up and rudder up on the good motor. Do we need to shut it down? Do we need to pull the condition lever on this prop that just feathered itself? Something is obviously wrong, but the POH doesn’t offer any guidance. Once again we’re back to dealer’s choice. It goes without saying that the mission is over. We turn towards home and start talking. If we choose to shut it down, as soon as we pull that condition lever back the N1 will wind down and our generator will kick off line. Do we need that electrical power? Let’s take a look at the gen loads – if they’re below 50% each, we can probably afford it. But if the weather is bad and we have anti-ice and radar blasting, they might just be at the limit. Not to mention that any mission equipment that didn’t get turned off prior to the shutdown is now powered by the operating generator. Canning the engine may result in a 100% gen load, which could begin to draw down the battery. If the prop is feathered and other indications seem OK, some pilots may elect to keep it running to keep the electrical system happy. After all, a feathered prop is the ultimate goal, right?

OK, we have a new airplane, a new day (yuck….that sounds too much like a UPT cliché - sorry). We’re cruising to the target area and the props are at 1500 RPM. It’s quiet. The airplane swerves a bit, and now it’s loud. We scan the gages and notice RPM on the left is at 1750. The primary governor failed. If it can’t hold the RPM at 1700, the overspeed governor steps in and begins to dump oil to prevent RPM in excess of 1768. Mechanically, it works the same way the primary governor works, except that it can only reduce oil pressure in the dome. But, if we can limit torque to 96%, we can continue operating. And we’d probably have an intelligent conversation about keeping the torque much lower than that unless we really needed it. Then we head home later on, and someone asks the question: Can we land with an overspeeding prop? We go to the POH. Nothing. Oh POH, why hast thou forsaken us? Landing with an overspeeding prop is a bad idea. There’s no telling what it will do when the flight low pitch stop retracts, or how it might behave during rapid power lever advancement in the case of a go around. In either case, the blade angle may flatten so rapidly that directional control becomes impossible. On final, smart pilots will add some power and rudder on the good side, shutdown the sick motor, and make a safe single engine landing.

What happens if both the primary and the overspeed governors have no effect on blade angle, such as in the case of a frozen propeller hub assembly? Lucky for us we have a fuel topping governor. This thing is effective and simple. It controls prop speed by reducing the P3 air to the FCU, which reduces the fuel spray to the combustion chamber. In turn, this will limit the power applied to the prop shaft and hopefully limit RPM to 106% of the selected setting. Put away your calculators, nerds, it’s 1802 RPM with props full forward. Don’t bother with the POH, it won’t tell you what to do. It does, however, mention that ground fine will reset the fuel topping governor to 95% of the selected RPM to drive the prop into an underspeed condition. Does this imply a safe landing can be made after the primary and overspeed governors have bailed on us? No, it just implies that the governor resets when we pull the levers over the detent. If you choose to land with the RPM governed only by fuel topping, there may not be enough fingers and toes on the airplane to keep crossed. Good luck with all that. Again, smart pilots will shut it down, but long before you get to final. The sooner the better, in fact, because your propeller is now on the verge of catastrophic failure.

Let’s back up to the scenario in which we’re cruising at 1500 RPM, and we feel a slight swerve and hear one of the props get louder. This time, we look and discover that the left prop is stable at 1700 RPM. Did we have a governor failure? What caused an uncommanded increase in RPM? The POH doesn’t talk about this, but you’ll find a brief comment in the pilot training manual about it. In this case, the primary governor is working just fine. After all, the prop is stable at 1700 RPM, right? It would be very easy to mistake this for a governor failure, but it’s the governor control linkage that failed, the linkage that enables pilots to control RPM. Now our primary governor is functioning exactly the way the overspeed governor does in an overspeed. It holds the RPM to the preset maximum, and we can no longer manipulate the setting. Lucky for us 1700 is perfectly safe and usable. With this malfunction, we don’t want to shut it down, and we’re not going to hurt anything by using reverse when we land.

Time to discuss a sneaky one, and we’re gonna do it in two parts: The failure, and the fix. Proper compressor bleed valve operation is essential to operation at both low and high power settings. It enables smooth acceleration as we add power, and prevents bog down when we reduce power. The valve opens and closes automatically by referencing the pressure differential between the axial and centrifugal compressors, and it snaps open and closed very quickly. You wouldn’t want to get your finger caught in that contraption. The failure: It’s possible for the valve to get stuck in a transient position, and the symptoms of a stuck valve are often confused with a flameout. The engine runs roughly for a moment before wheezing and winding down, or torque just drops off as you add power. It’s all pretty similar, however a few subtle differences may mean the difference between landing with both motors running or only one. The first difference is that this will only happen during power adjustments. The second difference is that we may see high ITT as the engine winds down. That is not characteristic of a flameout. And if you recognize this, you may be able to do something about it.

The fix: Let’s talk about opening up the No Starter Assist Airstart Checklist (aka Windmilling Airstart). And let’s assume we’re above our single engine service ceiling, so the only place to go is down. Gotta move quickly. Immediately we discover that this is an oppressively long, 18-step checklist. We curse aloud and wonder how a time-critical airborne relight can be accomplished with such a lengthy checklist, but really it can be done quickly. First we’re gonna power up and rudder up the healthy side (always the first step). Power idle, prop full forward, condition lever fuel cutoff. First three steps in one place. We’re quick. We have a few switch positions to check until we get to airspeed and altitude. Why 20,000 feet? Because airstarts tend to be hotter way up in the thinner air. But do you see those mountains down there? We’re gonna try it now. And if it gets too hot, the POH says we can cycle the condition lever to limit ITT. The auto ignition is already armed, so as soon as the condition lever hits low idle we should see something. And if not, desperation may tell our instincts to throw the IGNITION AND ENGINE START switch to ON. After a few agonizing seconds the engine relights! The angels begin to trumpet! The crowd goes wild! Prop full forward, power as required, and we’re flying with both motors again. As we start climbing away from the mountains we can finish the last few administrative checklist items. And if it doesn’t relight, shut it down to get that prop feathered and start talking about Plan B: an RTB for a single engine approach and landing.

Here’s an embarrassing reason to run the windmilling airstart checklist: In the King Air’s long history, pant legs have been caught on condition levers as pilots exited the seat, resulting in an inadvertent shutdown. Be careful. There’s not enough beer on the planet to buy back your dignity if you become *that* guy.

Windmilling airstarts are extremely reliable, but there are times when we’d prefer a Starter Assist Airstart. We just saw that ugly yellow L/R CHIP DETECT annunciator pop on, which tells us that we have some metal contamination in the oil supply. That’s not good. We reference the POH, which says to monitor indications and perform a precautionary shutdown at our discretion. “At our discretion” means NOW, guys. Or as close to now as we can get. Even with no secondary indications such as low oil pressure or high temp, the idea is to preserve the life of the engine in case we really need it later. It’s a half hour back to the house, and even back at idle an engine with an eroding gearbox isn’t gonna last that long. We power up and rudder up, then shut it down. We’re on the way back, and ATIS tells us that the field is at mins, and the Ops Sup says our alternate isn’t any better. A single engine go around is a real possibility today. Do we want to fly down to decision height with one engine or two? One technique is to run the Starter Assist Airstart checklist through step 9 and hold it until you’re on radar vectors. Now, we only have to throw the IGNITION AND ENGINE START switch to ON. The copilot can move the condition lever to low idle and monitor the start. Follow the checklist, jump on final, and land with two engines or go around with a drastic improvement to your climbout capability. Yet another technique is to leave it shutdown so it’s not failing catastrophically during the go around, causing all kinds of directional control problems at a very delicate moment in your aviation career. As we said, historically the life of an engine after the arrival of a L/R CHIP DETECT annunciator is short. And historically airstarts are extremely reliable in the King Air, so if you decide to go down that road it should fire right up. Talk it over with the crew and support the decision of the pilot with the A-code, because it’s a 50/50 situation.

***Takeoff Emergencies and Engine-out Landings***

This certainly has been an exhausting section, but hang in there for the final discussion: we’re gonna talk about techniques for engine failures on takeoff, single engine landings, and single engine go arounds. Today our left engine hates our guts, and all these scenarios are based on left engine failures.

Here’s the technique, the mantra that will save the crew and airplane during an engine failure on takeoff roll. Stop or continue, it’s still the same. If there were tablets with commandments for engine-out flying, this would be inscribed at the top of the list: In the event of an engine failure on takeoff, Step to the Line and Steer to the Line. Centerline, that is. We’d all like to think that good instincts would take over and we’d react quickly, correctly, and automatically. But even a momentary misapplication of rudder or aileron can have tragic results. A good departure brief should include a few words about losing an engine and stopping, and losing and engine and continuing. Let’s talk about stopping first.

We’re barreling down the runway with max power set. At 80 kts, the left engine winds down without warning. We swerve left violently, and the aircraft rolls left. Power comes to idle as we step to the line and steer to the line. This action immediately gets us coming back toward centerline reduces the tilt angle. Judge the rate of correction and assess the inputs. We want adequate input, not exaggerated input. A crosswind may be helping or hurting us, but predicting an engine failure is impossible, and we’re too busy and surprised to consider crosswinds cognitively. Let go of your ego, Maverick, and just accept this fact: the rate of correction and input assessment is mostly a function of instinct and monkey skill. On its way back to idle, the right power lever will pass 68-70% N1 microswitch and enable the singular engagement of the right ground idle stop, which will flatten the blade angle to +2 degrees and help us in our turn toward centerline. Assess the inputs once again. If we bring the levers into ground fine, the blade angle reduction will further coax us to centerline as it decreases toward zero thrust. Maybe we assess that we don’t need too much assistance back to centerline and ease up on the rudder. If we have a long runway, maybe we can skip ground fine altogether and stop with the brakes. But if we need it, we’ll use it. It’s better to flirt with both sides of the runway and stop than to exit the pavement perfectly on centerline. Think about how easily we might lose directional control if we pulled the lever all the way back into reverse. The POH has a warning against that, so ground idle is as far as we go. Were you wondering why the aircraft would roll left when the engine failed? Prop aircraft receive a considerable measure of lift from the airflow generated by the prop, and in this case only the right wing has that boosted lift, so we’d roll left (but not as violently as we’d swerve left, so rudder is king in this situation).

We’re barreling down the runway with max power set. Right after V1, the left engine winds down without warning. We swerve left violently, and the aircraft tilts left. We’re going for it, so step to the line and steer to the line. During the departure brief, some pilots set the expectation that the pilot not flying will automatically set 100% torque on the operating engine and apply about half the available rudder trim. We hit Vr and pitch up (with an armful of right aileron to find 5 degrees favorable bank, or at least keep it level). This pitch causes P-factor and torque to increase, both trying to yaw the nose left again. To maximize our chances of surviving, we must consider continuing a take off after an engine fails as a maneuver for both pilots. Suck up the gear and check to see that autofeather is working. More nerd trivia - The autofeather has a microswitch in the throttle assembly just like the flight low pitch stop. In order for it to work, both power levers must be at a position normally corresponding to 88% N1 or higher. And, obviously, it has to be armed. Duh. But it should be comforting to know that Hawker Beech has a 100% success rate with the autofeather system in the King Air. Dig out the checklist and bring it around for a single engine landing.

We’ve maneuvered a few miles from the airport as we climbed out. The left engine is feathered and standing tall, and we’re at a safe altitude to start planning our return. Time to talk. At this point we’re not too busy or surprised to consider crosswinds cognitively. We’d prefer a steady headwind, but suppose we took off with a direct crosswind, which we’re gonna have to accept for landing. From which side would we be most negatively affected by the effects of a strong wind? Can we do anything about it? Is it a long, wide runway that will allow an extended rollout? Or a short, narrow runway where stop distance and strict directional control are critical? The power on the right engine is currently yawing the nose left, and will continue to do so as we fight for centerline on final. A right crosswind will push on the vertical stabilizer, tending to bring the nose right. This is a nice rudder-reducing counterbalance, which will help achieve accurate centerline control on our descent to the runway. But what will that right crosswind do to us when we land? We put it down on centerline and the squat switch powers the engagement of the ground idle stop. The blades flatten and we swerve right. The yaw will be more pronounced if we have to apply ground fine to stop. All of a sudden that magically helpful right crosswind has become a nuisance, banging away on that vertical stabilizer and aggravating our directional control challenges. That’s bad news on a short, narrow runway. In this case, we’d rather have the crosswind over the dead engine side, countering the swerve caused by our necessary control inputs. Hopefully we have a wide, long runway so we don’t need ground fine. In this case the swerve from the singular engagement of the ground idle stop will be manageable, and a few carefully measured rudder inputs will be all it takes to keep us on the pavement. This is the conversation we should be having as we formulate our plan, before advising tower of our intentions.

When faced with a narrow runway and a stiff crosswind, here’s what you can find inscribed just below “Step to the Line, Steer to the Line” on the engine-out tablets of wisdom: Cool the Dead on Rollout. It will improve our odds every time. We can fight the unfavorable crosswind on final. Our power is set and we can trim the rudder for stable flight. The rollout is vastly more critical. If we have to accept a crosswind landing, put that wind vector over the dead engine. The tower might have to approve an opposite direction to keep us from going into the dirt. And if they don’t want to, remind them that it’s an emergency and we’re gonna do it anyway. Nevermind the healthy airplanes, they can hold or go around. If we rush this thing and don’t keep the airplane on the runway, the Old Man talks and we listen. He writes and we sign.

Welcome to the final section. We’re going to skip the intramural-level single engine go around from a straight in. That’s for junior pilots in diapers. Let’s man up and jump directly to the varsity, no – intercollegiate, no – professional arena in which we’re forced go around from a single engine circle. It’s all a question of which way to turn. With an engine out, the aircraft handles safely in turns to either direction. And it’s possible to maneuver left or right and still ensure that our crosswind Cools the Dead on Rollout. So the question must be, which direction of turn is going to complicate our lives if we need to go around? Today our left engine is out, so we want to keep our turns to the right. But what if we make the rookie mistake and choose the left base because it’s quicker? Think about a 20-30 degree left turn with the dead left engine down. We’re steady in the turn with about 60% torque on the right engine, coming down gradually. The right engine is tending to yaw and roll us left, so we’re balancing with some right rudder and right aileron. This is unnatural – we’re turning left, but we’re applying control inputs as though we’re in a slip. But we definitely need right rudder and aileron. Before we roll onto final, an F15 pulls onto the runway and we have to go around. From 20-30 degrees left bank, we add power on the right engine – which yaws and rolls us further left – while simultaneously applying heavy rudder and aileron inputs. We pitch up, increasing P-factor, which yaws and rolls us further left. Heavier rudder and aileron inputs. Maybe even full deflection. It has been computed that Vmca increases about 3 kts for every degree of unfavorable bank, with the baseline for favorable bank starting at about +5. That wasn’t a big deal a few moments ago because we were content in the turn. But now we want to stop turning and straighten out to track down the runway. It’s all so unnecessarily difficult and potentially dangerous, especially when a right base is available (terrain/traffic/threats/weather permitting).

Enough about that rookie business. With the left engine shut down, you and I are smart enough to set it up correctly. Even if we have to overfly the runway to find our right base, it’s worth it. We enter the right base with the dead engine up. That’s a good start. We have some right rudder and right aileron for the right turn. That seems normal. And when the F15 pulls onto the runway and we have to go around, powering up that right engine is going to help level the wings as we roll out of the turn. And, we have less bank angle to correct before we’re back above Vmca. It’s still not easy, but it’s far less challenging and dangerous that going around from a turn into the dead engine.

One final Nerd Alert: Vmca is actually higher when it’s colder than 15C, the conditions for STP at which the Vmca speed is certified for an aircraft. That’s because prop performance is better in cold air, and the yaw from that single engine at max power is more pronounced. Publishing a steady value for Vmca may be accurate for that snapshot in time when it was certified, but it can be a bit misleading for some considerations.

Fuel System Diagram



Electrical System Diagram



Engine Diagram



Prop Diagram



